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ASSESSMENT OF CORAL REEFS CONDITION IN MOLOTABU WATERS BONE BOLANGO DISTRICT

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Abstrack

The assessment of the the coral reefs in the waters needs to be done in order to ensure the survival of fish and humans. The aim of the research was to assess the current state of the coral reefs in Molotabu waters, Bone Bolango District, Gorontalo Province. The assessment was consisted of the coral reef's condition, coverage percentage, life form categories, and also threat. Site location was divided 4 station. Data collection was conducted by using line transect method placed at depth of 3 meters and 10 meters respectively. The condition of the coral reefs was analyzed by referring to KEPMENLH No. 4/2001. Water quality was tested in which including: salinity, temperature, pH, dissolved oxygen and water brightness. Results showed that the *Coral Massive* was dominant form at depth of 3 meters, whereas at 10 meters no significant different between life form types. The highest coverage shown by coral reefs at 10 meters depth of 47,1%. The percentage gives the figure about the bad condition of the coral reefs in Molotabu waters.

Keywords: Assessment, Coral Reefs, Molotabu Waters

I. INTRODUCTION

Coral reefs are one of the major marine ecosystems that support marine life's productivity and high economic value. Coral reefs function as a place to spawn, feed, marine life habitat, and as a source of germplasm as well as the livelihoods of fishing communities through various activities as well as tourist attractions. Furthermore coral reefs are also a source of bioactive substance raw materials which is useful in pharmacy and medicine, and no less important function is as coastal protection from degradation and erosion, but currently coral reefs in Indonesia has undergone many alarming degradation (COREMAP, 2009).

Coral reef ecosystem is one of the aquatic ecosystems with high level of productivity. The existence of these ecosystems can be found in almost all Indonesian waters, including in the Gulf of Tomini where yellow-fin tuna is nurtured (Ministry of Environment, 2009). Sustainability of the tuna is largely determined by water conditions. Coral reefs can grow well when environmental conditions conducive to its growth. The sea around Molotabu Village is part of the Gulf of Tomini.

Sahami & Hamzah (2012), the condition of coral reefs in the waters around Molotabu Village were in the status of "averagely damaged" with live coral coverage of 48%. The extent of damage will increase if no serious treatment or management is taken and this may affect the life of associated organisms in it that support the sustainability of the fishery resources in the future.

Human activity is the largest contributor to the current destruction of coral reefs in addition to their natural activity. One such human activity is physical development in coastal areas. Currently, a Steam Powered Electric Plant (PLTU) is operating in Molotabu Village which will of course impose an impact on the coral reefs in the waters around it if the coral reefs management is not done properly. To be able to carry out such management, availability of data and information is a necessity. For an optimum management of water resources, it is important to understand the response of organisms in dealing with the changes that occur (Sahami, 2007). It is well known that water management can not be done directly. Therefore, an effort to make an assessment of the condition of coral reefs in the waters around Molotabu Village is needed. Such activity covers the coverage percentage and growth form categories, status of coral reefs condition and threats to coral reefs in the region. Results of this study are expected to provide basic information on the sustainable management of coral reefs, especially in the Village of Molotabu and Gulf of Tomini in general and as a basis for determining the future management of it.

II. RESEARCH METHOD

The research was conducted for 6 (six) months from February to August 2014, in the waters around Molotabu Village, Kabila Bone District, Bone Bolango Regency which is part of the Gulf of Tomini. Figure 1 shows the location of the research.

Figure 1 **Rearch site map (Source: Google Map, 2014 - edited)**

The research is divided into several stages as follows:

1. Observation
   This observation phase is done by using RRA (Rapid Reef Resources Assessment). This phase was conducted to determine the extent and form of habitat as well as the overall condition of the study area. Results of activity at this stage are used as a basis in determining the research stations and the laying of transect points.
2. Station Determination
   Based on observation, the research site are divided into four stations, namely Station 1 is located in front of the rather dense residents area where gazebos are situated on the beach for tourism development, the station coordinates are 00°26'01,2 "N - 123°07'56,1 "E. Station 2 is located in front of power plant at coordinate position 00°25'52,8" N - 123°08'04,2 "E. Station 3 is located in front of a rather sparse residential area at coordinates 00°25'45,7 "N - 123°08'10,1" E. Station 4 is located in front of Bimoli Factory dockyard at coordinates 00°25'33,9 "N - 123°08'12,9" E. Transect line laying is at the depth of 3 meters and 10 meters on each and every station.

3. Data collection

Data taken are of water quality data and coral reefs data. Water quality data collection was done in-situ which includes measurement of temperature, salinity, pH, dissolved oxygen, and brightness parameters. Data on coral reef ecosystems are represented by data on form of coral reefs growth which were conducted by Line Intercept Transect (LIT). LIT method is used to estimate the closure of coral coverage and benthic communities that live along with the reef. Such benthic community is then marked by using lifeform categories which give morphological description of reef communities. Categories are recorded by researchers on a paper placed along a line roughly parallel to the reef crest at the depth of 3 m and 10 m at each station (UNEP, 1993).

Assessment of the coral reef condition is done by analysing live coral coverage according to the Standard Criteria issued by the Decree of Ministry of Environment No. 04-2001, as follows:

Table 1 **Assessment of the condition or quality of life of the reef based on percentage of living coral coverage**

Parameters	**Standard Criteria of Coral Reef Damage (%)**		
Percentage of Living Coral Coverage	Damaged	Bad	0,0 – 24,9
		Average	25,0 - 49,9
	Good	Good	50,0 - 74,9
		Very Good	75,0 – 100

III. RESULTS AND DISCUSSION

3.1. Water Qualities at Research Site

Results of measurements of water quality parameters at the time of the study are presented in Table 2 below.

Table 2 Average Value Water Qualities at Research Site

No	**Station**	**Water Qualities**				
		Temp. (°C)	**Salinity (‰)**	**DO (mg/l)**	**pH**	**Brightness (%)**
1	I	32,5	32	2,4	9	100
2	II	30,8	32	1,6	8	100
3	III	31	31	4,4	8	100
4	IV	30	32	4,5	8,8	100

Table 2 shows that the measured parameters are still within the range that can be tolerated by coral reefs except pH parameters. The value of the measured temperature is approximately 30 – 32,5^{0}C. According to Nybakken (1992), the temperature is one of the very important factors in regulating the process of life and the spread of organism. Development of the most optimal reefs occur in waters that has average annual temperature of 23 – 25^{o}C and coral reefs can tolerate temperatures up to 36 - 40°C. Salinity measured at the study site ranged from 31-32 ‰. Supriharyono (2000), salinity suitable for the growth and formation of coral reefs is 27-35 ‰. In general, the salinity of the study sites is affected by rainfall. The time of the study coincides with the end of the rainy season. High rainfall can lead to dilution of sea water, which can lead to declining of salinity.

Results of DO (dissolved oxygen) measurement ranging from 1.6 to 4.5 mg/l. Dissolved oxygen in the water comes from the process of water plants photosynthesis depending on the density and intensity of light reaching into the water bodies (Effendi, 2003). The low value of DO at Station 2 may be caused by cloudy weather and early moning when measurement took place, thereby affecting the photosynthesis process.

pH values measured at the study site are relatively little bit high and it ranged between 8 and 9. According to Nybakken (1992), waters with pH values between 7 and 8 can be tolerated by most of the aquatic biota. The high pH value at Station 1 may be caused by pollution from household waste in Station 1. While the high pH value at Station 4 may be influenced by the boats activity at the pier nearby. In Mukhtasor (2007) it is stated that sea transportation can be a source of marine pollution such as solid waste, scraped plastic, waste of food and beverage, wastewater, and water ballast.

Brightness levels at all stations is good enough reached the bottom at 3 meters and 10 meters depth. This indicates that the brightness of the study site is very favorable for the growth of coral reefs in the waters. Brightness is largely determined by the color of the waters, the content of organic materials and inorganic suspended in the water, the density of plankton, microorganisms, and detritus (Sumich, 1992).

3.2. Coral Reefs in the Research Site

The coral reefs in the waters around Molotabu Village are of fringing reef type with steep to ramps up topography. The coral reefs in these waters grow on a flat area towards the edge of the reef with varying depths up to 30 meters. Overall found 12 forms of coral growth that consists of 5 growth forms of the genus Acropora namely *Acropora branching* (ACB), *Acropora tabulate* (ACT), *Acropora encrusting* (ACE), *Acropora submassive* (ACS), *Acropora digitate* (ACD); and 7 growth forms of non-Acropora genus, namely: *Coral branching* (CB), *Coral massive* (CM), *Coral encrusting* (CE), *Coral submassive* (CS), *Coral foliose* (CF), *Coral mushroom* (CMR), dan *Coral millepora* (CME).

a. Coral Coverage at 3 Meters Depth

Percentage of coral coverage at depths of 3 meters is presented in Table 3 with values relatively varied between stations. The average percentage is 33.75%.

Table 3 Percentage of coral coverage at depths of 3 meters in each station

No	Growth Forms	Coverage (%)				Average (%)
		Station I	Station II	Station III	Station IV	
	Live Coral					
	Acropora branching (ACB)	1.6	2.6	8.8	6	4.75
	Acropora tabulate (ACT)	2.4	10.8	1.6	4.2	4.75
	Acropora encrusting (ACE)	0	0	3.4	0	0.85
	Acropora submassive (ACS)	0.6	3.2	1.2	3.8	2.2
	Acropora digitate (ACD)	0.4	15.6	3.4	1.4	5.2
1	Coral branching (CB)	2	2.6	1	0	1.4
	Coral massive (CM)	10.6	11.6	10.6	15	11.95
	Coral encrusting (CE)	0	0	0	0.4	0.1
	Coral submassive (CS)	2.4	2	1	0	1.35
	Coral foliose (CF)	0	0	1.4	0	0.35
	Coral mushroom (CMR)	0	0	0	0.2	0.05
	Coral millepora (CME)	0	0.4	0.8	2	0.8
	Coral heliopora (CHL)	0	0	0	0	0
	Total	**20**	**48.8**	**33.2**	**33**	**33.75**
	Criteria of Coverage	**Poor**	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Dead Coral:					
2	Dead coral (DC)	0.4	0.4	0	1.6	0.6
	Dead coral with Algae (DCA)	5	9.2	6.6	6	6.7
	Total	**5.4**	**9.6**	**6.6**	**7.6**	**7.3**
3	**Algae :**					
	Makro algae (MA)	0	9.8	3.4	2.6	3.95
	Total	**0**	**9.8**	**3.4**	**2.6**	3.95
4	Soft coral	0	1	3.4	0	1.1
	Total	**0**	**1**	**3.4**	**0**	1.1
5	**Other (OT)**					0
	Other (OT)	0.2	0	0.4	0.2	0.2
	Total	**0.2**	**0**	**0.4**	**0.2**	**0.2**
6	**Abiotik:**					0
	Sand (S)	24	17.2	42.4	41.8	31.35
	Rubble (R)	2.2	2	0	1.8	1.5
	Rock (RCK)	48.2	11.6	10.6	13	20.85
	Total	**74.4**	**30.8**	**53**	**56.6**	**53.7**

Based on the results of the calculation of living coral coverage percentage of at the depth of 3 meters (Table 5) it can be seen that on average, the condition of reefs are at moderate criterion (33.75%). Furthermore, it can be seen that the percentage of living coral coverage was lowest at Station 1 with poor criterion (20%). The living coral coverage at a depth of 3 meters for each station illustrated in the graphs presented in Figure 2.

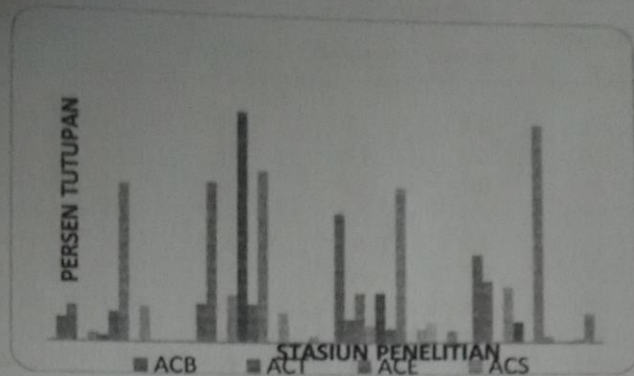

Figure 2 **The living coral coverage at a depth of 3 meters for each station based on its *life form* categories**

Figure 2 shows that the highest percentage of live coral coverage at 3 meters depth is Acropora digitate (ACD) in Station 2 and in general the percentage of live coral coverage that has a high value at all stations is Coral Massive (CM). In Panggabean & Setiadji (2011) it is explained CM coral colonies occupy the edge region and are found in the open water environment. This is consistent with observations, whereas the research site is mostly cliffs and open areas. According to Panggabean & Setiadji (2011) that this type of coral is more resistant to changes in water quality and resistant to quite strong wave and current pressure than other categories of coral forms.

In addition to the assessment of the percentage of living coral coverage, assessment of the percentage of other categories was also conducted (Table 3). Percentage comparison between categories is presented more precisely in Figure 3.

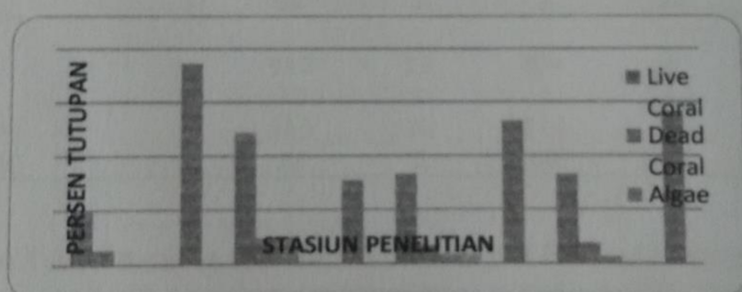

Figure 3 Percentage comparison between coverage of live coral, dead coral, algae, soft coral, other biotic and abiotic at 3 meters depth.

Figure 3 shows that the abiotic coverge category is the one that stands out. It can be seen that successively the highest to the lowest percentage of abiotic coverage is at Station 1, 4 and 3, while at Station 2 coverage is dominated by live coral.

b. Coral Coverage at 10 Meters Depth

Percentage of coral reefs coverage at 10 meters depth in the study site is presented in Table 4. The results show that the percentage of live coral coverage on each station is quite varied.

Tabel 4 **Percentage of coral coverage at depths of 10 meters in each station**

No	Growth Forms	Coverage (%)				Average (%)
		Station I	Station II	Station III	Station IV	
	Live Coral					
1	Acropora branching (ACB)	6.8	4	8.6	3.6	5.75
	Acropora tabulate (ACT)	4.2	13.6	0.6	5.4	5.95
	Acropora encrusting (ACE)	0.6	4.8	5.8	0	2.8
	Acropora submassive (ACS)	1.4	4.6	6	6.6	4.65
	Acropora digitate (ACD)	0	1.4	0.8	1	0.8
	Coral branching (CB)	6.8	5.4	1.6	7.2	5.25
	Coral massive (CM)	2.2	5.6	4.2	8.6	5.15
	Coral encrusting (CE)	10.2	3.8	2	6	5.5
	Coral submassive (CS)	0	4	3.2	4.8	3
	Coral foliose (CF)	1.2	4.8	7.2	0.6	3.45
	Coral mushroom (CMR)	1.6	0	0.6	3.8	1.5
	Coral millepora (CME)	1.6	9	0	2.6	3.3
	Total	**36.6**	**61**	**40.6**	**50.2**	**47.1**
	Criteria of Coverage	**Moderate**	**Good**	**Moderate**	**Good**	**Moderate**
2	**Dead Coral :**					
	Dead coral (DC)	0	0	0	0	0
	Dead coral with Algae (DCA)	1.2	2.2	1.8	3.4	2.15
	Total	**1.2**	**2.2**	**1.8**	**3.4**	**2.15**
3	**Algae :**					
	Algae assembly (AA)	0	0	0.6	0	0.15
	Total	**0**	**0**	**0.6**	**0**	0.15
4	Soft coral	0	0	3.4	0.4	0.95
	Total	**0**	**0**	**3.4**	**0.4**	0.95
5	**Other (OT)**					
	Sponge (sp)	6.2	6	2.8	4.4	
	Other (OT)	0.6	0	0.2	0.2	0.25
	Total	**6.8**	**6**	**3**	**4.6**	**0.25**
6	**Abiotik:**					0
	Sand (S)	12.8	3.8	25.4	9	12.75
	Rubble	7.2	2	3	14.4	6.65
	Water (WA)	32.8	25	21.4	11.4	22.65
	Rock (RCK)	2.6	0	0.8	6.6	2.5

Based on Table 4 it can be seen that the percentage of live coral coverage at the depth of 10 meters is averagely 47.1% with the highest percentage found in Station 2 (61%). Comparison of live coral coverage at the depth of 10 meters for each station illustrated in the graphs presented in Figure 4.

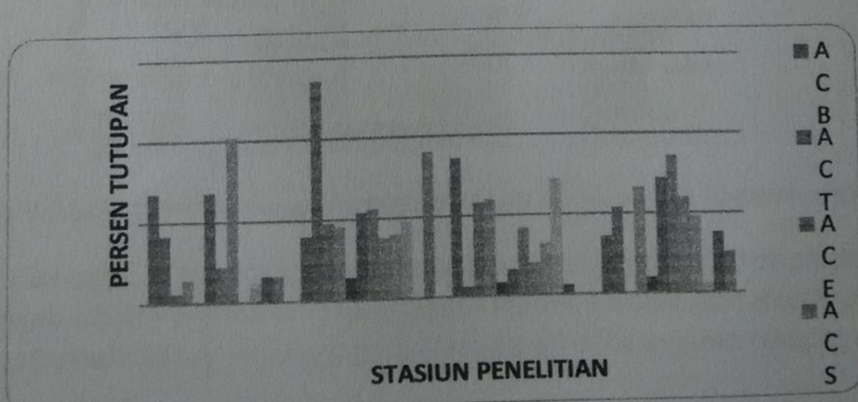

Figure 4 The living coral coverage at a depth of 10 meters for each station based on its *life form* categories

Figure 4 shows that the percentage of coverage based on lifeform of living coral at the depth of 10 meters vary. Station 1 is the highest form of Coral encrusting (CE) with a value of 10.20%, at Station 2 forms of growth with the highest percentage owned by Acropora tabulate (ACT) with a value of 13.6%, at Station 3 with a value of 8.6%, and at Station 4 is the massive Coral (CM) with a value of 8.6%. In general, averagely the highest lifeform at all stations at 10 meters depth is the Acropora tabulate (ACT) with a value of 5.95%. Acropora Tabulate that grows side-widely covers other coral species and blocks the light that enters into the waters. It can slow the growth of other types of coral beneath. According to English, et al., (1994), competition between the coral biota can affect the existence of other coral reef.

Based on Table 4 the coverage percentage of live coral, dead coral, algae, soft corals, other biotic and abiotic vary at each station. The details of percentage difference can be seen at Figure 5.

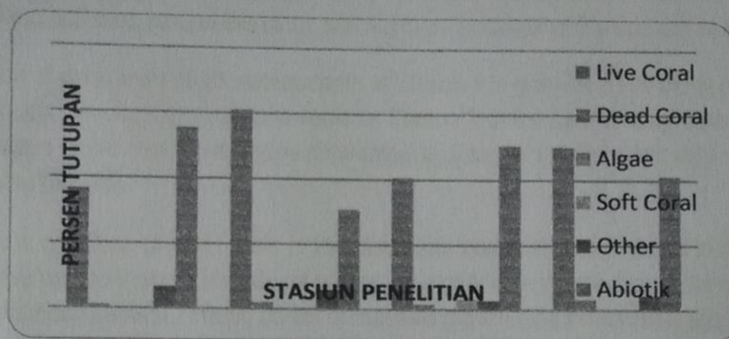

Figure 5 Percentage comparison between coverage of live coral, dead coral, algae, soft coral, other biotic and abiotic at 10 meters depth.

Figure 5 shows that there are different levels of coverage between stations. At Station 1 and 3, coverage is dominated by abiotic, while at Station 2 and 4, coverage is dominated by live coral.

3.3. Coral Reef Status on Research Site

Based on Table 5 and Table 6, status of coral reefs in the study site at depth of 3 meters and 10 meters averagely are in the moderate category (percent coverage at 3 meters depth is 33, 75% and at 10 meters depth is 47.1%). Comparison of percentage based on the depth presented in Figure 6.

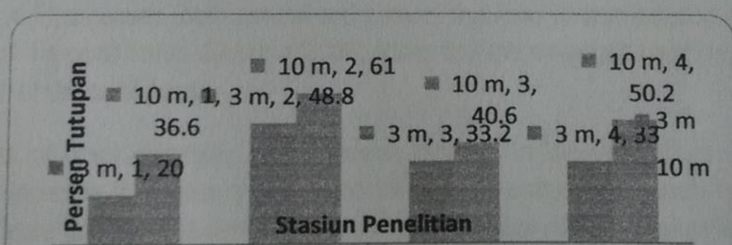

Figure 5 Comparison of Coverage Percentage of Live Coral at 3 and 10 meters depth.

Figure 6 shows the condition of coral reefs in the two different depths, at 10 meters the percentage of live coral coverage is higher than that at 3 meters depth. At Station 1 the condition of coral reefs at depths of 3 meters are in the bad category and at a depth of 10 meters are in the moderate category. For Station 2 at 3 meters depth is in the category of moderate and at 10 meters depth in good categories and generally status of coral reef conditions at Station 2 can be said to be good. At Station 3 both at 3 meters and 10 meters depth is in moderate category. For Station 4 at 3 meters depth is in moderate category, while at 10 meters depth is still in good category.

The low percentage of live coral coverage at Station 1 at 3 meters depth caused by the abundance of abiotic substances (sand and stone). The condition of the substrate in the form of sand and stones enables the coral growth in the future. As Sukarno (2001) explained that the growth of hard coral found on hard substrates such as dead coral and sand. Such substrate conditions are suitable for attachment of young coral colonies as well as for the growth and development of the reef.

Based on the observation that along the transect line are found Coral massive new growth (young coral colony), it seems that the coral in this site is in a state of self-recovery. Maybe a few years ago the coral reefs were damaged by un-environmentally friendly fishing activities. Local fishermen admit that they do not engage in fishing activities around the study site anymore because of the scarcity of fish.

The condition of coral reefs at 10 meters depth at Station 1 in general is still pretty good compared to the depth of 3 meters. The condition of coral reefs at Station 2 is the best among other stations. At 3 meters depth percentage of live coral coverage is dominated by *Acropora digitate* and at10 meters depth is dominated by *Acropora tabulate*.

Generally, the condition of coral reefs in the study site based on the average percentage of live coral coverage is in the category of moderately damaged. This condition can be worsened or refined in the future depending on its management. Young corals of massive growth type in its young age and other biota that associated with coral reefs are found abundant. Some assosiated biotae found in the study site are Asteroidea (*Linkia laevigata*), bivalves, especially the species *Tridacna sp*, Holothuroidea, Anemone, Nudibranchia, Ophiuroidea, and Crinoidea.

3.4. Threat to the Coral Reefs in Research Site

Bleaching is begining to happen at all station bringing risky threat to the coral growth that could lead to extinction. Bleaching of coral reefs can be caused, among others; by abnormal high temperatures, high level of ultraviolet light, lack of light, high turbidity and sedimentation, disease, abnormal salinity and pollution (Santoso 2006).

In Westmacott, et al., (2000) explained that coral bleaching (i.e. becoming pale or snowy-white) occurs due to various causes, both natural and human, that lead to degeneration or loss of the coloring *zooxanthellae* of the coral tissue. Santoso (2006) states that the prolonged bleaching (over 10 weeks) can cause the death of the coral polyp.

Causes of coral bleaching vary between regions. In Westmacott, et al., (2000) noted that geographically, increase in frequency and mass bleaching damage are caused by average increase of surface temperature and there is certainly enough evidence that climate change is the main cause. Sea temperature rise is a serious threat to coral reefs.

If assessed according to KEPMENLH No.4 – 2001, the average condition of coral reefs in research site is moderately damaged. The power plant located near the site has been operating and producing hot waste water and dust emissions from the use of coal. Hot water Waste and dust emissions will have worsening impact on coral reefs today if not managed properly.

Interestingly, the results show that live coral coverage condition is better at Station 2 which is closer to the power plant than other stations. Therefore, as the least attempt to maintain the current conditions, waste water management should remain consistent to the provisions agreed jointly. By that also, the condition of coral reefs at this time can be increased or at least will not be worse than the current conditions. To foster coral reef conservation management, the power plant and related agencies need to do a periodic and continuous monitoring on coral reefs condition around the Molotabu Village.

IV. CONCLUSIONS AND SUGGESTIONS

Based on the research results, it can be concluded as follows:

1. The percentage of coral coverage at 3 meters and 10 meters depths are different, i.e. 3 meters depth is dominated by the massive Coral categories, while at 10 meters depth the spread of growth form is more evenly.
2. The condition of coral reefs in the waters around Molotabu Village is in damaged status.
3. Bleaching is the main threat to coral reefs in the waters around the Molotabu Village.

Things that can be recommended for the preservation of coral reefs and the sustainability biota in the waters around Molotabu Village are as follows:

1. Continuous monitoring of water quality and the condition of coral reefs by installation of permanent transects to facilitate monitoring.
2. Proper household waste management.
3. Proper waste water and dust emission management from the power plant.

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